

CAREER: Exploring Nanostructures Based on Atomically Ordered 2D Dopant Patterns in Si

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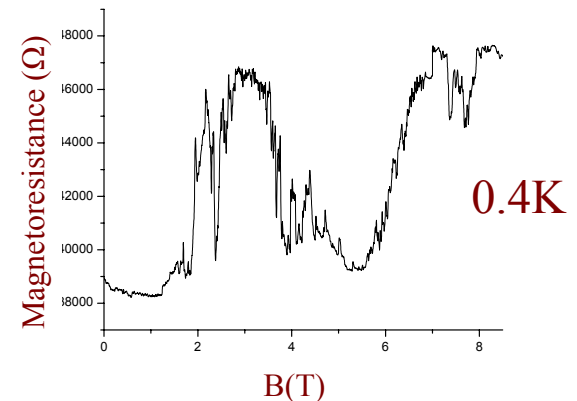
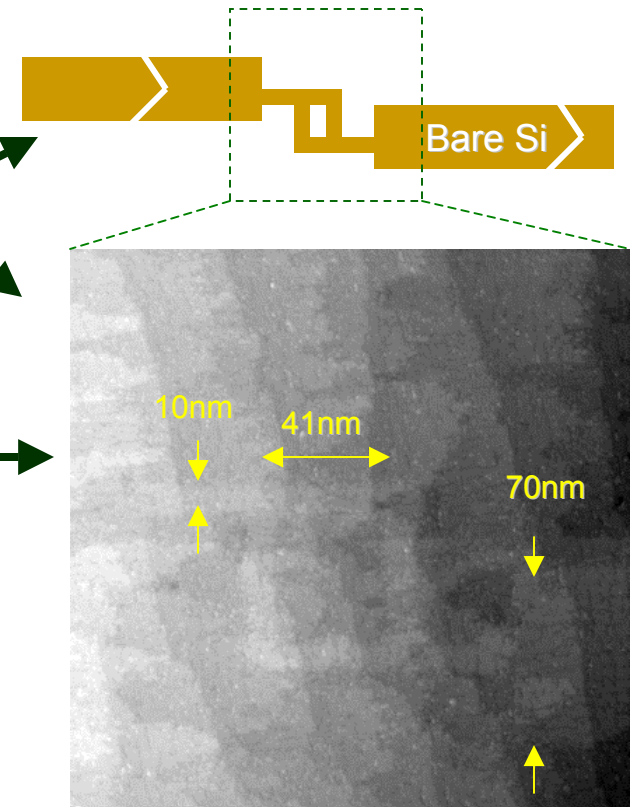
Lithography: A 10nm-linewidth square ring with 70 nm-wide leads composed of bare Si atoms is patterned on an H-covered Si(100) device template with As implanted contacts overlap with the leads.

Materials

Developed an ultrahigh vacuum process to clean and smooth the As implanted templates to atomic level.

Need to control the purity of PH_3 gas exposure and subsequent Si growth conditions to minimize crystal defects. The electrons from P atom form a two-dimensional electron gas in the patterned region.

Device: Applying a perpendicular magnetic field, the electron wavefunctions in this ring will interfere with each other and the resistance between the two leads show periodicity in the magnetic field - known as Aharonov-Bohm effect.



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Broader impacts:

We have shown that phosphorous atoms can define nanoscale electronic circuits in a crystalline silicon. Unlike other nanoscale structures built on silicon surfaces, such as carbon nanotubes, this technique provides reproducible electrical contact, eliminates surface and bulk defects on devices and can integrate quantum tunneling devices in the current microelectronics for very fast and charge-sensitive applications.

Educational contributions:

- 9 undergraduates and 3 graduate students contributed significantly to this project.
- Won 4 Undergraduate Research and Creative Opportunities (URCO) awards from USU.
- Undergraduates Andrew Millward, Richard Hatch, and Michael Lee are in Ph.D programs of physics and chemistry. Toby Barrus and Rodrick Draney finished their M.S. degrees in physics and electrical engineering, respectively.
- Two Ph. D. theses (J.-Y. Ji and Jeff Kline) are based on the research in this project.
- 29 researchers in physics and materials have been invited to present their works at USU Physics Colloquium.